

# ENVIRONMENTAL PROTECTION

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## AN ENVIRONMENTALLY SAFE ADDITIVE IN THE PRODUCTION OF PORCELAIN ARTICLES

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It is demonstrated that introduction of an environmentally safe strengthening additive, namely molasses, into the composition of a porcelain mixture based on Gusevskii stone contributes to increasing the mechanical strength of the intermediate product.

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One of the conditions for producing competitive products in a market economy is the use of technologies which along with a high level of quality provide for a decreased consumption of resources, especially the energy and labor resources per product unit. This problem can be solved by using additives that have a beneficial effect on the process and on the finished good quality. Such additives should be accessible (i.e., available and inexpensive) and serve as a basis for environmentally clean technologies.

The strengthening of air-dried intermediate porcelain products can be accomplished by using such additives as phosphate compounds, polyvinyl acetate emulsion, polyvinyl alcohol, sulfite-alcohol distillery grain slops, and others. However, the use of the known additives is impeded by the following undesirable consequences:

- formation of a film on the product surface, which decreases the open porosity and, consequently, impedes glazing (orthophosphoric acid and phosphate compounds) [1];
- a decrease in the plasticity of the porcelain mixture (polyvinyl acetate emulsion) [2];
- a substantial increase in the shrinkage of mixtures in the dried and fired states (polyvinyl alcohol) [3].

Furthermore, the above additives are the products of the chemical industry and their application involves a certain risk to human health.

The most widely used additive increasing the mechanical strength of an intermediate porcelain product in air-dried state is sulfite-alcohol distillery grain slops (SAS) that are generated as waste by the paper-and-pulp industry [3]. It is known that introduction of 1% SAS into a porcelain mixture increases the mechanical strength of air-dried samples by

60 – 70%, and the time of milling of the mixture in a ball mill therewith decreases by 10%.

However, when SAS is used as a strengthening additive in porcelain mixtures based on the Gusevskii stone (dacite porphyry) used at the porcelain factories of the Primorskii Region, a cracking film emerges on the surface of the intermediate product after drying and impedes its glazing. Furthermore, transportation of the said additive from the Perm and Yaroslavl Regions involves certain difficulties and expenses.

To solve different aspects of the problem, we propose to improve the technology of producing porcelain mixture by adding molasses, which is waste generated by the local sugar industry, into the mixture composition. The chemical composition of molasses, like any product of vegetable origin, is extremely complicated [4]. In addition to saccharose, it contains other mono-, di-, and oligosaccharides, heterocyclic bases, amino- and carbonic acid, organic pigments, and other chemical compounds. The majority of them have a natural origin, and some are formed as a result of chemical transformations of natural compounds in the technological process. Molasses can also contain various impurities introduced at different stages of processing materials. However, in spite of this, molasses represents an environmentally safe product.

As molasses represents a natural complex of biologically active compounds, it preserves all the positive properties that are imparted to a porcelain mixture by the currently used additives (increasing the mechanical strength in the air-dried state, decreasing the milling duration). At the same time, the use of molasses is not accompanied by such undesirable consequences as excessive and nonuniform shrinkage or difficulties in subsequent glazing.

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TABLE 1

Properties of porcelain mixtures	Content of additive, %						
	0	0.65	1.35	2.0	2.5	4.0	6.0
Decrease in milling duration, %	—	5.0	11.7	13.3	13.3	15.0	16.7
Residue on a No. 0056 sieve, %	1.22	1.25	1.21	1.23	1.22	1.22	1.21
Specific surface area, m <sup>2</sup> /g	414.3	—	420.0	449.0	455.0	425.9	419.4

TABLE 2

Properties of porcelain materials	Content of additive, %						
	0	0.65	1.35	2.0	2.5	4.0	6.0
Air shrinkage, %	4.84	4.79	4.40	4.17	4.23	4.11	4.08
Static bending strength, MPa:							
in air-dried state	5.5	5.7	6.2	6.6	7.0	8.6	9.4
fired at 850°C	6.1	6.0	5.9	5.8	5.7	5.6	5.6
fired at 1350°C:							
non-glazed	93.5	92.6	91.9	91.9	91.0	89.8	89.5
glazed	106.5	105.4	103.0	102.3	101.1	99.1	98.9
Water absorption of samples* fired at 850°C, %	16	17	17	17	17	18	18

\* Samples fired at 1350°C (nonglazed and glazed) had virtually zero water absorption.

Thus, the molasses proposed for use as a strengthening additive makes it possible to effectively solve all the above problems. Being essentially an additive with a comprehensive effect (which was proved in our experiment) molasses exhibits surfactant and electrolyte properties and influences the mechanism of interaction of the initial component of the porcelain mixture in various stages of the structure formation.

The reference mixture used in the studies contained materials in the following ratio (wt.%): 50 dacite, 10 Enskoe pegmatite, 23 Chalganovskoe kaolin, 4 Latnenskoe clay, 7 Troshkovskoe clay, 6 broken porcelain waste after the second firing. Besides, 7% broken porcelain after the first firing was added above 100%. The experimental mixtures additionally contained 0.65 – 6.00% molasses (above 100%).

The procedure of preparing experimental porcelain mixtures was as follows: all mixture components were loaded into a ball mill in the ratio of 3 kg of initial components per 2.7 kg of water and 5.5 kg of milling bodies (uralite balls). Milling was continued to a residue of 1.2 – 1.3% on a No. 0056 sieve [5]. The duration of milling of the initial components to a required dispersion level in industrial conditions is 5 h. In preparing experimental porcelain mixtures it decreased by 5.0 – 16.7% (Table 1).

The introduction of the proposed method for producing a porcelain mixture makes it possible to increase the mechanical strength of the intermediate product in the air-dried state to the level typical of an intermediate production subjected to the first firing at 850°C (Table 2). The use of molasses as a strengthening additive did not cause excessive shrinkage of the porcelain material and preserved the open porosity necessary for the glazing process.

The specific surface area of the reference mixture prepared in accordance with the formula of the Vladivostok Porcelain Factory without the additive amounted to 414.3 m<sup>2</sup>/g, that of the mixture containing 1.35% molasses as a strengthening additive was 420.0 m<sup>2</sup>/g, and that of the mixture with 2.5% molasses was 455.0 m<sup>2</sup>/g (Table 1). The bending strength of air-dried intermediary porcelain products made of these mixtures was equal to 5.5, 6.2, and 7.0 MPa, respectively. The highest effect of surfactants is observed under concentrations at which a monomolecular layer is formed. If the concentration is above the optimum level, the effect is significantly less perceptible, which is related to aggregation of surfactant molecules due to the chemical bonds arising between their polar groups [6].

An analysis of the experimental data revealed the positive effect of using the additive in the amount 1.35%.

Thus, there are prerequisites for making porcelain products from mixtures with the molasses additive in single firing. The elimination of the first (nonglaze) firing from the process will make it possible to reduce the consumption of diesel fuel, which, in turn, ought to decrease the pollution of the ambient environment.

The economic effect of the proposed method for producing porcelain mixture using molasses as a strengthening additive is determined by savings in material and fuel resources, a decrease in the technological waste and rejected products, and a decrease in the wear of machinery.

## REFERENCES

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